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Feasibility Study to Convert Existing Unutilized Tobacco Barns for Drying Chillies

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ABSTRACT

Currently there is a need for large scale artificial drying system using hot air to overcome quality issues, cyclone threats and sometimes to dry storm affected chilli crop. Guntur and Prakasam districts in Andhra Pradesh have large number of unutilized tobacco barns due to decline in tobacco cropping area. These areas have been mostly replaced by chilli which has a post harvest problem of drying. Experiments were conducted in Dharanikota village of Amaravathi Mandal in Guntur district of Andhra Pradesh to investigate feasibility of converting existing tobacco barns to dry chillies. It has been found that 11 to 11.5 quintals of ripe chillies can be loaded in the existing tobacco barns to dry chillies depending upon the size of the barn, initial moisture content and type of chilli.Galvanized iron (G.I) wire mesh trays of size 1.05 x 0.75 x 0.075 m were found to be suitable to hold chillies on the existing tiers of the barn. The drying time required to dry chillies was found to be 48 to 50 hours in comparison to 19 days in the open yard method of drying.

Key words : Barn, Chillies, Drying.

The present open yard sun drying of chillies involves exposing the produce to atmospheric vagaries for about 15 to 20 days leading to poor colour retention, contamination with dirt, animal excreta etc. Currently there is a need for large scale artificial hot air drying system that can dry at least 10 quintals of ripe pods per batch (Satyanarayana & Sukumaran, 2002). Guntur and Prakasam in Andhra Pradesh are traditionally cotton, tobacco and chilli growing districts. However in the last decade due to reduction in demand for tobacco from black cotton soil tracks, cultivation of tobacco has become unviable and the cropping area has been mostly replaced by chilli. These districts on an average have at least twenty to twenty five unutilized tobacco barns in tobacco growing villages. Tobacco barns are masonry constructions that are used for curing and drying of tobacco. Five full and two extra small span tiers (at the top of roof) exist in tobacco barns. Major components of tobacco barn are; I. Lean to type roof building, roof is usually made of Galvanized iron (G.I)sheet; 2. Super structure is usually of masonry of brick or stone; 3. Furnace; 4. Flue pipes and 5. Ventilators. Tobacco barns use natural convection type flue pipe indirect system for curing and drying green leaf. Hot air generated by burning coal or fire wood is used to dry the leaves. Opening, closing of top and bottom ventilators and regulation of fuel in the furnace are used to control drying temperature inside the barns. Each barn costs about 1.0 to 1.5 lakhs depending upon size. Most of the barns are now either abandoned or being dismantled to sell for scrap. Hence a study was undertaken to conduct feasibility study for utilization of existing tobacco barns to dry chillies by proposing minimal alteration/modifications in the existing barn structure to make it suitable for drying of chillies.

MATERIAL AND METHODS

Preliminary work concentrated around design of suitable size of holding material such as mats or trays to spread ripe chillies and place the trays/ mats along with ripe pods on the existing tiers to expose them to the hot air in the barn. All the experiments were performed at Dharanikota village in Amaravathi mandal of Guntur district, Andhra Pradesh using a single furnace type barn of size 3.6 x 6 m. Bamboo grills/mats of size 0.75 x 1.8 m were locally made using bamboo reapers of about 20 mm width. The bamboo mats were placed on the existing tiers and chillies were spread on them. All of the existing tiers in the barns were loaded with chillies after leaving a central bay of 0.6 x 6 m for ease of loading as well as for circulation of hot air in the barn. Locally grown popular hybrid namely "wonder hot" (high colour, low to medium pungency type) was procured from the local farmer. The hybrid is preferred in the market due to high colour value and required biochemical qualities. In all the experiments, fruits were harvested a day before and allowed to heap over night to facilitate uniform development of colour.

Experiments were also conducted using wire mesh trays made up of G.I. and stainless steel of

size 105 x 75 x 7.5 cm. The G.I. wire mesh trays were fabricated by welding three number G.I wire mesh (three holes in square inch) to the frame made of 12 mm M.S flat. Four handles of length 15 cm each were welded at four corners of the tray for easy handling as well as to place on the existing tiers. Similarly stainless steel wire mesh trays were made by a local commercial fabricator.

Experiments were also performed using G.I wire mesh trays at different thickness of spreads (loading densities). Chillies were spread at different thickness 5, 6.25 and 7.5 cm in separate experiments to investigate its effect on drying time and loading capacity. The thickness of 6.2 cm is same as that is mostly followed by farmers in open yard sun drying. The average bulk density of wonder hot hybrid chilli is 230 Kg/m^3 at an initial moisture content of 233.3 to 237 % (db). The loading densities corresponding to thickness of 5, 6.25 and 7.5 cm are 11.5, 14.4 and 17.25 kg/m^2 for this hybrid chilli. The loading capacity of the barn was 9.1, 11.25 and 13.6 quintals respectively at the three different loading densities investigated.

Drying experiments were conducted at an input capacity of 11 to 11.5 quintals of ripe fruit. About the same quantity of ripe pods were also spread on the floor at the same thickness to collect data in farmer's method (open yard sun drying). Initial and final moisture contents of the produce were measured using AOAC method (AOAC, 1955).

Two different temperature measuring devices were used in the study apart from farmers way of using curometer, which is an ordinary thermometer attached to a metal strip. The temperature could be read through the inspection window by pulling the curometer inside the barn using an arrangement of small pulley and strings. Two temperature buzzers (ITC-ILTD-Make) are fixed one at the top most tier and the other at the bottom most tier. The battery operated buzzers have low and high temperature alarms to alert the operator to maintain drying air temperature in pre determined range. Also two thermocouple probes cum humidity sensors, dry and wet bulb hygrometer (Zeal-make, U.K.) were placed at different points to record drying air temperatures and humidity. These measuring devices enabled to regulate the temperature by manually opening and closing of both bottom and top ventilators and required action of regulating fire wood feed rate in the furnace.

Percentage of discolored pods both in open yard and barn drying methods was calculated by separating them from red pods and weighing. Biochemical quality parameters such as ASTA colour, capsaicin content, ethyl dichloride (EDC) extracted oleoresin content and total aflatoxin content were determined as per the procedure of official analytical methods of the American Spice Trade Association (ASTA, 1997).

RESULTS AND DISCUSSION

Experiments indicated that ripe chillies at an initial moisture of 236.1% (db) could be dried to a final moisture content of 11.5% (db) in about 70 to 80 hrs depending on the location of bamboo mats on the tiers (Table. 1). The produce on the first tier (lower most tier nearer to flue pipe) took about 70 hrs to dry whereas the produce on the second, third, fourth and fifth tiers took 72, 75, 78 and 80 hrs respectively. The experiments demonstrated that drying time varies with the position of the tier. The drying time is a maximum of 80 hours *i.e* 3 to 4 days in comparison to 19 days required in open yard sun drying. The variation of 70 to 80 hours in drying time using bamboo mats is due to variation in drying air temperature across the height of the barn. This is perhaps due to heat losses through the bare G.I roof of the barn and poor recirculation of the hot air within the barn.

The color of the barn dried product as measured by colour value is higher than the product obtained by open yard drying (Table.1). Discolored pods are found to be only 1 to 2 % in barn dried produce compared to 12 to 14% in open yard sun drying. The aflatoxin content of barn dried produce is much lower compared to that obtained in open yard method. It is evident from the experiments that quality of barn dried chillies is superior in comparison to produce obtained in farmer's method (Table 1).

Effect of tray holding material

Experiments with bamboo mats as holding material revealed that bamboo mats, although of low cost initially, can not be used on large scale and for drying in batches on a continuous basis. The main disadvantage with bamboo mats appears to be poor heat and mass transfer rates leading to longer drying time and also poor durability. Experiments were conducted at a drying air temperature of 55 °C with the same hybrid chilli at the same thickness of about 6.25 cm to investigate the effect of different tray holding material on drying time. A total of 100 trays were loaded on the existing tiers of the barn. The capacity of the barn was found to be 11 to 11.5 quintals. Drying times were found to be much lower

Table 1. Summary of experimental results of barn and open yard sun drying of "wonder hot "chillies using bamboo mats at a thickness of 6.25 cm

Parameter	Barn drying	Open yard sun drying
Initial Moisture content (dry basis, %)	236.1	236.1
Final Moisture content (dry basis, %)	11.5	11.5
Drying temperature (^{0}C)	50 to 55	—
Drying time	70 to 80 hrs	19 days
Discolored pods (%)	1 to 2	12 to 14
ASTA colour*	92 to 99	73 to 75
Oleoresin (%)	12.8 to 13.8	12.3 to 13.2
Capsaicin (%)	0.21 to 0.28	0.20 to 0.26
Aflatoxin, ppb	<0.5**	27

*American Spice Trade Association, **Limit of detection is 0.5 ppb

Table 2. Summary of experimental results of barn drying of "wonder hot "chillies using G.I and stainless steel wire mesh trays at a thickness of 6.25 cm

Parameter	GI wire mesh trays	SS wire mesh trays
Initial Moisture content (dry basis, %)	234.2	234.2
Final Moisture content (dry basis, %)	11.5	11.5
Drying temperature (^{0}C)	50 to 55	—
Drying time	48 to 50 hrs	47.5 to 51 hrs
Discolored pods (%)	1 to 2.5	1.5 to 2
ASTA colour	90 to 97	93 to 95
Oleoresin (%)	12.0 to 13.2	11.3 to 12.8
Capsaicin (%)	0.20 to 0.26	0.21 to 0.25
Aflatoxin, ppb	<0.5	<0.5

with perforated trays, 47.5 to 51 hours (Table. 2) in comparison to drying using bamboo mats (Table 1). The drying times are almost in the same range with both the type of holding materials (Table 2). However the drying time still varied from 47.5 to 51 hours across the vertical height of the barn when wire mesh trays are used.

Effect of Chilli thickness

The average drying time was relatively shorter, 43 to 45 hours at thickness spread of 5 cm whereas the drying time was 55 to 60 hours at a thickness of spread of 7.5 cm (Table.3). Also some non uniformity in drying of pods was observed at a loading thickness of 7.5 cm. About 7 to 10% pods were found to be partially dried particularly in the top tiers. It is possible to overcome this problem using a forced circulation system. However this leads to more modifications in the barn and also enhanced cost of conversion due to requirement of blowers etc. More over power supply in the fields is not always available.

Effect of drying air temperature

Hence further experiments were conducted using a thickness of spread of 6.25 cm as it is found to be better in terms of drying time and also uniformity of drying. Further experiments focused on optimizing drying air temperature. It is well known that as the temperature of the drying air is increased, drying time is generally reduced. Separate laboratory studies at the Post Harvest Technology Center,

Table 3. Summary of experimental results of barn drying of "wonder hot "chillies using G.I wire mesh trays at different thicknesses.

Parameter	Thickness of spread		
	5 cm	6.25 cm	7.5 cm
Initial Moisture content (dry basis, %)	236.1	234.8	235.1
Final Moisture content (dry basis, %)	12.1	11.5	11.5
Drying temperature (^{0}C)	50 to 55	50 to 55	50 to 55
Drying time	43 to 45 hrs	48 to 50 hrs	55 to 60 hrs
Discolored pods (%)	1.5 to 2.75	1.5 to 2.5	2 to 2.5
ASTA colour	80 to 94	94 to 97	92 to 94
Oleoresin (%)	11.5 to 12.2	11.4 to 12.6	11.0 to 12.50
Capsaicin (%)	0.19 to 0.25	0.22 to 0.26	0.17 to 0.22
Aflatoxin, ppb	<0.5	<0.5	<0.5

Table 4. Profile of average drying air temperatures inside the barn

Between flue pipe and bottom tier (Tier 1) (curometer reading)	50°C	55°C	60°C
Between Tier1 & Tier 2	48.5	53.5	58.0
Between Tier 2 & Tier 3	47.5	52.0	56.5
Between Tier 3 & Tier 4	45.5	50.5	54.0
Between Tier 4 & Tier 5 (Top Tiers)	44.0	48.5	52.5

Table 5. Time, Temperature and ventilator operating regimes to dry hybrid chilli in barns

Time (hrs)	Temperature regimes (^{0}C)	Ventilator position	
		Bottom ventilators	Top Ventilator
0 to 6	50	Full closed	Full closed
6 to 44	55	Half open	Full open
44 to 50	55	Full open	Full closed

Bapatla and work of Lease and Lease (1962), Mishra (1972) suggested that 60°C is critical temperature to avoid darkening/blackening of chilli in artificial drying. Hence experiments were conducted at different drying air temperatures of 50, 55 and 60° C using wonder hot hybrid. Considerable variation ranging from 6 to 7.5 °C in drying air temperature across the height of the barn was observed in the experiments (Table. 4). The temperature profiles (Table. 4) and visual observation of dried produce in different tiers indicated that the drying air from 50 to 55°C is suitable to dry chillies with good colour retention in the barn.

Optimization of operating regimes

Experiments also indicated that chillies in bottom tiers dried faster as compared to top tiers. Moisture removal is higher in bottom tiers during initial stages of drying, whereas moisture removal in top tiers, in early stages is slow. The movement of drying front is from bottom to the top of the barn as the heating is taking place from bottom to top tiers. This leads to relatively over drying in bottom tiers and under drying in top tiers. The problem which exists in tobacco drying also is usually overcome by systematic operation of bottom and top ventilators. Such type of information was generated in the present study to dry chillies in barns. A suitable schedule for uniform drying of wonder hot hybrid chilli was developed (Table 5).

Establishment of barn drying procedure

The following general procedure is recommended to dry chillies in the barns. The produce must be heaped atleast 12 hours prior to loading into barn for development of uniform color and ripening of any unripe fruits. The produce has to be spread evenly in all the trays. It is suggested to close all the ventilators both top, bottom and inspection window before start firing the furnace. The temperature within the barn has to be checked using curometer, so that it reaches from ambient to 50°C within 5 to 6 hours to pre warm the barn and product. Then the bottom ventilators have to be opened half and top ventilator has to be opened completely, so that drying starts. During the period of 0 to 6 hours, sweating of produce takes place leading to migration of moisture to surface of the pods. The surface moisture would be removed effectively when the ventilators are opened to initiate drying. The ambient air which enters through the bottom ventilators gets heated up and removes moisture from the pods and exits through the top ventilator. The temperature in the barn has to be maintained at about 55°C for about 38 hours by regulating the feed rate of the fire wood. The moisture content of the pods has to be checked frequently by opening inspection window which is near the fourth tier. As the pods in the lower tiers dry quickly in comparison to pods in the top tiers, when about 80% of the pods of top tier are dried (about four pods in a sample of five), the top ventilator has to be closed completely keeping all the bottom ventilators fully open. By following this operating regimes, the ambient air which touches the hot flue pipes, reaches the top tiers through the bed of already dried produce in the bottom tiers and stays in the top tiers to remove moisture from the undried pods in the top tiers. This regime has to be continued for about 6 hours, so that about 20% undried pods in the top tiers would also get dried thereby ensuring uniform drying in all the tiers. Then finally the top ventilator has to be opened completely and fire is stopped. After about one hour, all ventilators, inspection window and main door have to be opened to cool the produce and equilibrate with ambient conditions. The produce can be unloaded by spreading a taurpalin sheet on the floor of the barn and emptying the trays starting from bottom tiers. Dried chillies can be packed in gunny bags when the moisture is sufficient without breakage of pods.

CONCLUSIONS

1.The time required to dry chillies in barns using bamboo mats varies with the position of the tier. The drying time is a maximum of 80 hours *i.e.* 3 to 4 days comparison to 19 days required in open yard sun drying.

2. Drying times were found to be much lower with perforated G.I and stainless steel trays, 48 to 50 hours and 47.5 to 51 hours respectively, in comparison to drying using bamboo mats. The drying times are almost in the same with both the type of perforated holding materials.

3.The average drying time was relatively shorter, 43 to 45 hours at a thickness spread of 5 cm whereas the drying time was 55 to 60 hours at a thickness of spread of 7.5 cm. Optimum thickness of spread was found to be 6.25 cm.

4.It is feasible to dry ripe chillies in the existing tobacco barns by spreading them at a thickness of 6.25 cm on G.I. wire mesh trays of size 105 x 75 x 7.5 cm and placing on different tiers of the barn.

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